

### **Indicator: Ambient Concentrations of PM (003)**

Particulate matter (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air. Airborne PM comes from many different sources. Primary particles are released directly from emissions sources into the atmosphere, while secondary particles are formed in the air from reactions involving precursor chemicals (e.g., nitrogen oxides, sulfur dioxide). Ambient air monitoring stations throughout the country measure air concentrations of two size ranges of particles: PM<sub>2.5</sub> and PM<sub>10</sub>. PM<sub>2.5</sub> consists of “fine particles” with aerodynamic diameters less than or equal to 2.5 µm. PM<sub>10</sub> includes both fine particles (PM<sub>2.5</sub>) and “coarse particles,” which are particles with aerodynamic diameters between 2.5 and 10 µm. The heavier PM<sub>10</sub> particles tend to exhibit more localized effects, whereas PM<sub>2.5</sub> tends to exhibit a more regional effect as the primary and secondary particles that form it are more easily transported. PM<sub>2.5</sub> also has a seasonal pattern because some of the secondary particles involved in its formation vary by seasonal emission and/ or transport (EPA 2002B).

Scientific studies show a link between inhalable PM, which includes both fine and coarse particles that can accumulate in the respiratory system, and a series of significant health effects. Some of these effects are associated with exposures to PM, while others are associated with exposures to a combination of PM and other air pollutants. Exposure to coarse particles is primarily associated with the aggravation of respiratory conditions such as asthma. Exposure to fine particles is closely associated with decreased lung function, increased hospital admissions and emergency room visits, increased respiratory symptoms and disease, and premature death. Sensitive groups that appear to be at greatest risk to such PM effects include the elderly, individuals with cardiopulmonary disease such as asthma or congestive heart disease, and children (EPA2002a).

PM also can cause adverse impacts to the environment. Fine particles are the major cause of reduced visibility in parts of the U.S., including many of our National Parks and wilderness areas (see Indicator 006). PM deposition affects vegetation and ecosystems by upsetting delicate nutrient and chemical balances in soils and surface water. For example, deposition of particles containing nitrogen and sulfur may change the nutrient balance and acidity of aquatic environments so that species composition and buffering capacity change (see Indicator 041). Some particles that deposit onto plant leaves can corrode leaf surfaces or interfere with plant metabolism. PM also causes soiling and erosion damage to materials, including monuments, statues, and other objects of cultural importance.

This indicator describes trends in ambient air concentrations of PM, based on measurements from a nationwide network of monitoring stations.

### **What the Data Show**

PM<sub>10</sub> concentrations averaged across the 434 monitoring stations in operation between 1988 and 2004 are currently 31% lower than the average 1988 levels, with most of this decrease occurring between 1988 and 1996 (Figure 003-1). The baseline year (1988) was selected because widespread PM<sub>10</sub> monitoring did not occur in earlier years. PM<sub>10</sub> concentrations for the ten EPA Regions all experienced steady decreases in PM<sub>10</sub> levels (Figure 003-2). The greatest decreases were observed in Regions 9 and 10, the two EPA regions that had the highest PM<sub>10</sub> levels in the baseline year. While the ambient condition for PM<sub>10</sub> is clearly improving, airborne particulate concentrations continue to be a health issue in certain parts of the country. In 2003, 37 counties (21 million people) measured concentrations in excess of the PM<sub>10</sub> standards (EPA 2004).

Average PM<sub>2.5</sub> concentrations in 2003 were the lowest since nationwide monitoring began in 1999 (Figure 003-3). The baseline year (1999) in this case is the first year when widespread PM<sub>2.5</sub> monitoring occurred, and the trend is based on measurements collected at 785 monitoring stations that generated high

quality data over that period. Improvements were most significant in portions of the West (Region 9) and the Southeast (Region 4), where average PM<sub>2.5</sub> levels in 2003 were 18% lower than those in 1999 (Figure 003-4). However, average PM<sub>2.5</sub> levels in the Rocky Mountains (Region 8) and New England (Region 1) were essentially unchanged over the period. In 2003, 72 counties (53 million people) measured concentrations in excess of the PM<sub>2.5</sub> standards (EPA 2004).

### **Indicator Limitations**

- There are far more PM<sub>10</sub> and PM<sub>2.5</sub> monitors in urban areas than in rural areas.

### **Data Source**

US EPA Air Quality System (<http://www.epa.gov/air/data/index.html>).

Interagency Monitoring of Protected Visual Environments Network and EPA Speciation Network, 2002

### **References**

U.S. Environmental Protection Agency. Air Quality Criteria for Particulate Matter, Third External Review Draft, Volume II, EPA 600-P-99-002bC. Research Triangle Park, NC; US Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, April 2002A.

U.S. Environmental Protection Agency. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. 2002b

U.S. Environmental Protection Agency. The Particulate Pollution Report: Current Understanding of Air Quality and Emissions through 2003, EPA 454/R-04-002. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, December 2004.

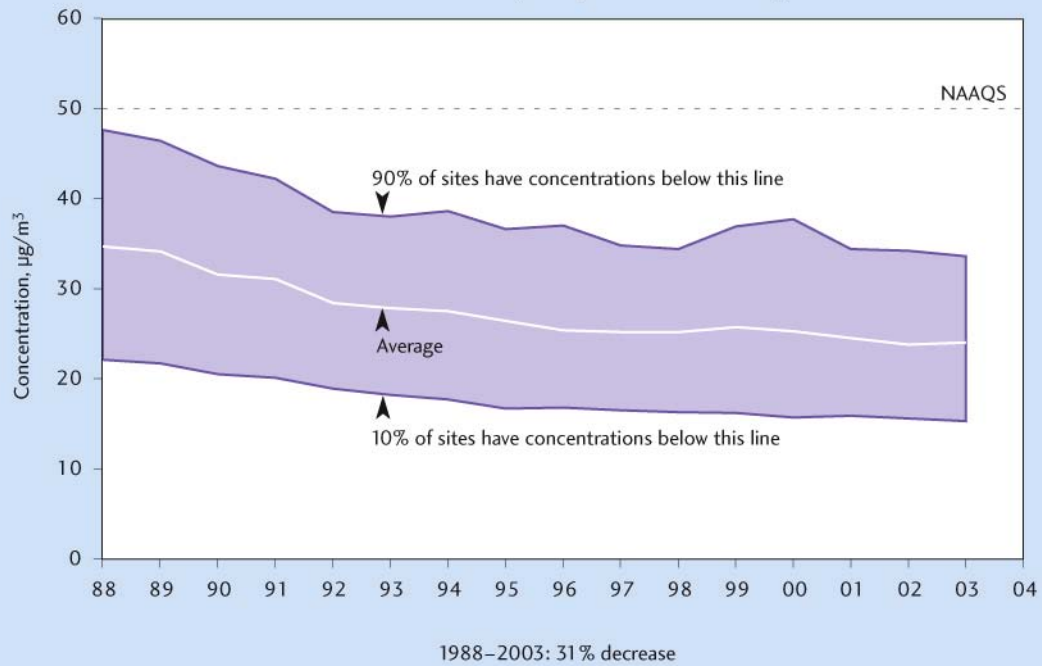
Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001.)

U.S. Environmental Protection Agency. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

## Graphics

Figure 003-1: Particulate matter ( $PM_{10}$ ) air quality, 1988-2004  
Based on seasonally weighted annual average

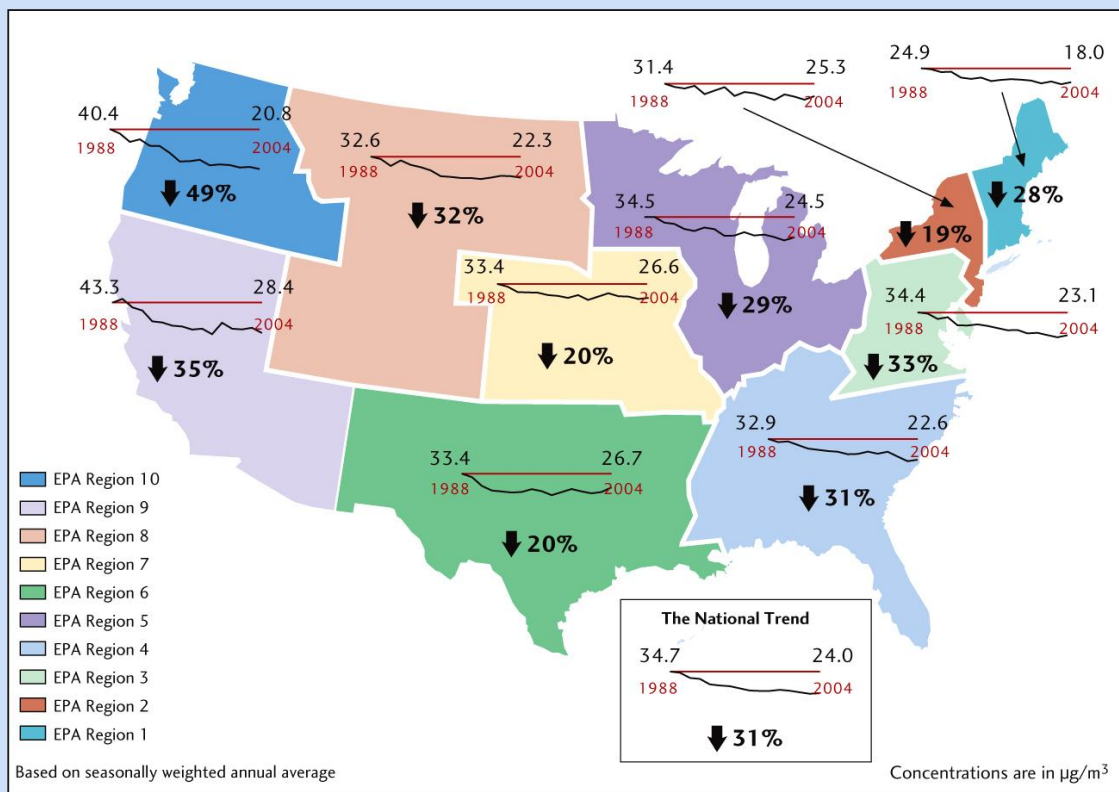


Coverage: 434 monitoring sites nationwide with sufficient data to assess trends.

Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

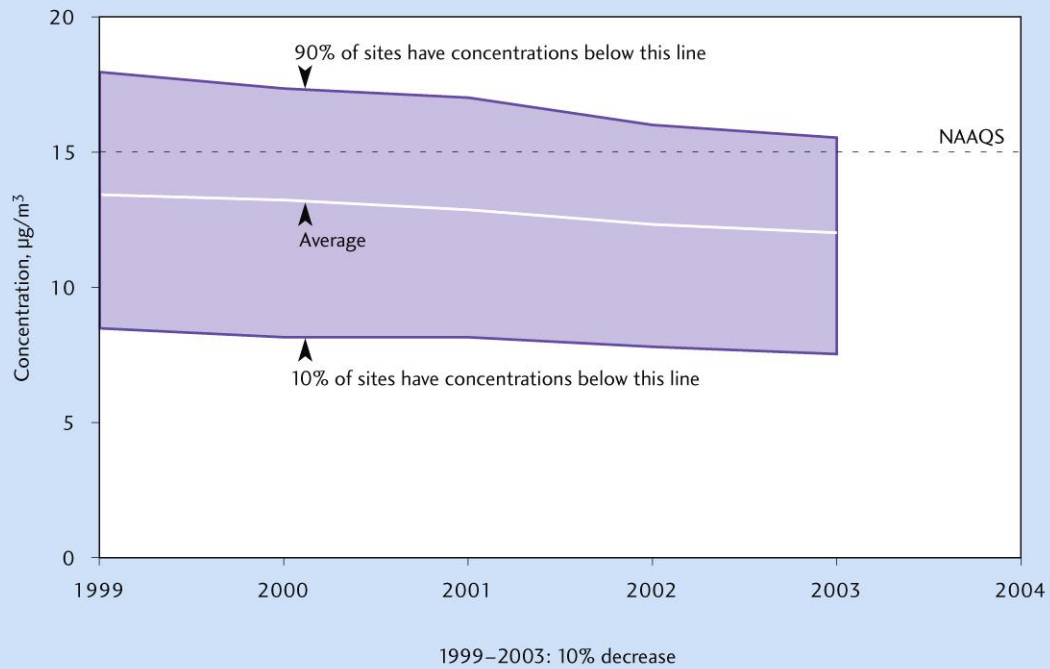
Figure 003-2 : Trends in particulate matter ( $PM_{10}$ ), 1988-2004, averaged across EPA regions



Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

Figure 003-3: Particulate matter ( $PM_{2.5}$ ) air quality, 1999-2004  
Based on seasonally weighted annual average

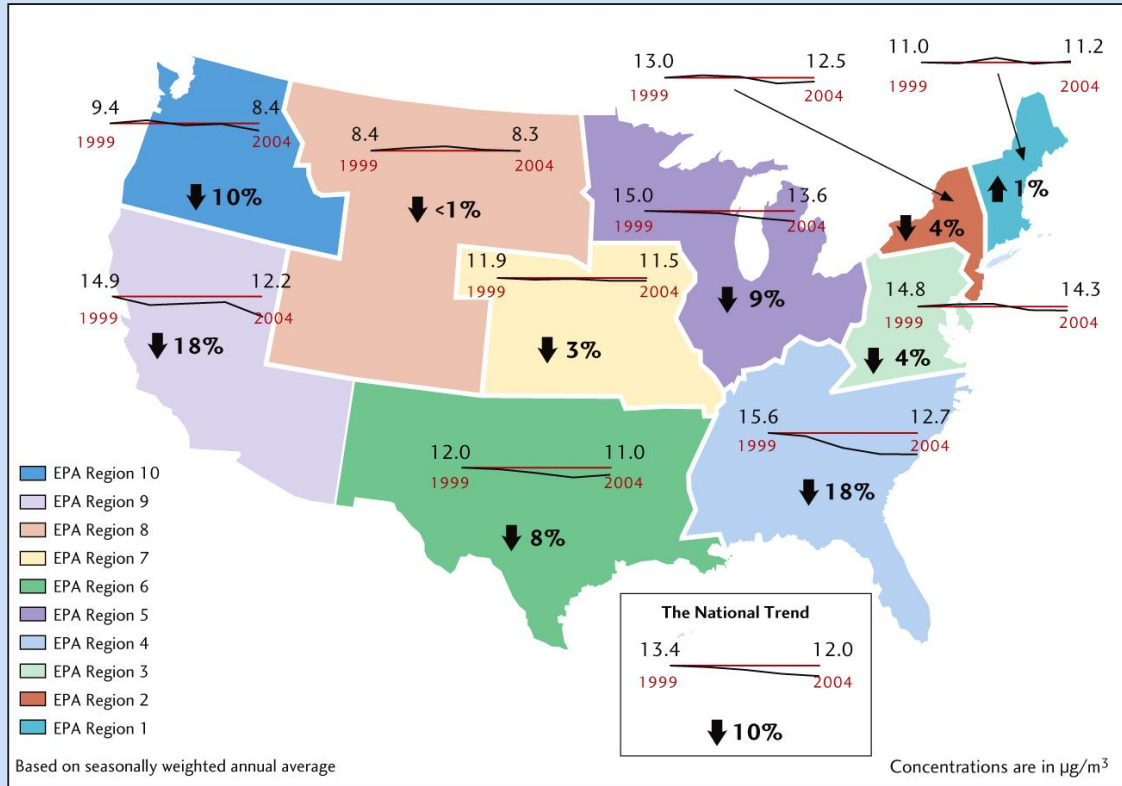


Coverage: 785 monitoring sites nationwide with sufficient data to assess trends.

Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

Figure 003-4: Trends in particulate matter ( $PM_{2.5}$ ), 1999-2004, averaged across EPA regions



Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

## **R.O.E. Indicator QA/QC**

**Data Set Name:** AMBIENT PM CONCENTRATIONS

**Indicator Number:** 003 (89072)

**Data Set Source:** EPA Air Quality System

**Data Collection Date:** 1988-2004

**Data Collection Frequency:** Varies. See 40 CFR Parts 53 & 58 & attached QA/QC

**Data Set Description:** Ambient PM Concentrations

**Primary ROE Question:** What are the trends in outdoor air quality and effects on human health and ecological systems?

### **Question/Response**

**T1Q1** Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The ambient air quality data are based on data retrieved from the Air Quality System (AQS) in August 2004. These are direct measurements of pollutant concentrations at monitoring stations operated by tribes and state and local governments throughout the nation. The monitoring stations are generally located in larger urban areas. EPA and other federal agencies also operate some air quality monitoring sites on a temporary basis as a part of air pollution research studies. The national monitoring network conforms to uniform criteria for monitor siting, instrumentation, and quality assurance. The program under which the data are collected is the NAMS/SLAMS network. 40 CFR 53 - Process for determining reference or equivalent methods for determining criteria air pollutant concentrations in the atmosphere " 40 CFR 58 - Ambient air quality surveillance (monitoring) requirements These results have been peer reviewed. The most recent review was as a part of the National Air Quality and Emissions Trends Report, 2001 EPA 454/K-02-001, September 2002. This report is available at: <http://www.epa.gov/airtrends>. In addition, the Interagency Monitoring of Protected Visual Environments (IMPROVE) network was established in 1987 to track trends in pollutants such as PM<sub>2.5</sub> that contribute to visibility impairment. These sites are located predominantly in rural areas throughout the country and the data is useful for assessing regional differences in PM<sub>2.5</sub>.

**T1Q2** Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. In 2002, thousands of monitoring sites reported air quality data for one or more of the six National Ambient Air Quality Standards (NAAQS) pollutants to AQS, as shown in Table B-1. The sites consist of National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS), and other special-purpose monitors. NAMS were established to ensure a long-term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent database for air quality comparisons and trends analysis. SLAMS allow state or local governments to develop networks tailored for their immediate monitoring needs. A description of this network includes: " 40 CFR 50 - National ambient air quality standards (NAAQS) and reference methods for



determining criteria air pollutant concentrations in the atmosphere "  
([http://www.epa.gov/ttn/oarpg/t1/fr\\_notices/pmnaaqs.pdf](http://www.epa.gov/ttn/oarpg/t1/fr_notices/pmnaaqs.pdf) )

**T1Q3** Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The conceptual model used to derive these indicators has been used and thoroughly reviewed as part of the Agency's national report on air quality trends for 25 years. Particulate matter air quality monitoring sites meet the annual trends data completeness requirement if they have at least 30 daily measurements per year for PM10 or at least 11 daily measurements for each calendar quarter for PM2.5. The model basically has three elements: 1.) Determine if year is valid for inclusion. Must have greater than or equal to 30 daily measurements per year for PM10. Must have greater than or equal to 11 daily measurements for each calendar quarter for PM2.5. 2.) Determine if site is valid for trends. Must have greater than or equal to 75% of possible years in the time series. The national PM10 monitoring network started in 1988. For the 16-year period 1988-2003, trend sites must have at least 12 valid years and must not be missing more than 2 consecutive years of data. The national PM2.5 monitoring network started in 1999. For the 5-year period 1999-2003, trend sites must have at least 4 valid years. 3.) Interpolate for missing years. Simple linear interpolation is used to fill in for missing years in the following way. Missing annual summary statistics for the in-between years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates. References include: U.S. Environmental Protection Agency. The Ozone Report - Measuring Progress through 2003, EPA 454/K-04-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, April 2004. Latest Findings on National Air Quality 2002 Status and Trends, 2003, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003. The Particle Pollution Report, 2003, EPA 454-R-04-002. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, December 2004.

**T2Q1** To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The national air monitoring network for the six criteria air pollutants is extensive; however, there are far more monitors in urban areas than in rural areas. Monitoring in urban areas helps to characterize population exposures, because population tends to be concentrated in urban areas. More rural monitoring might help scientists assess transport and ecological effects, although EPA uses additional tools and techniques (e.g., models and spatial analyses) to augment limited monitoring in some areas and to better characterize pressures on ecological condition. EPA is currently conducting a national



assessment of the existing ambient monitoring networks and is analyzing, among other issues, the need for and appropriateness of each of the nation's urban monitors.

**T2Q2** To what extent does the sampling design represent sensitive populations or ecosystems?

The network is not focused on sensitive populations like children, the elderly, asthmatics, etc., but samples them proportion to their occurrence in the general populations of the areas monitored.

**T2Q3** Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes, the levels of the corresponding national ambient air quality standards (NAAQS) for PM<sub>2.5</sub> are 15 ug/m<sup>3</sup> (annual) and 65 ug/m<sup>3</sup> (24-hour). The levels of the corresponding NAAQS for PM<sub>10</sub> are 50 ug/m<sup>3</sup> (annual) 150 ug/m<sup>3</sup> (24-hour). These levels are indicative of the state of the environment with respect to ambient air concentrations of particulate matter. The annual averages are more stable than peak 24-hour metrics and, therefore, are used for tracking long-term trends.

**T3Q1** What documentation clearly and completely describes the underlying sampling and analytical procedures used?

National Air Quality and Emissions Trends Report, 2003 Special Studies Edition - <http://www.epa.gov/air/airtrends/aqtrnd03/> General Air Quality and National Monitoring Network - <http://www.epa.gov/ttn/amtic/moninfo.html> PM 2.5 Monitoring Information - <http://www.epa.gov/ttn/amtic/amticpm.html>

**T3Q2** Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. The data used to develop these indicators are available through the Air Quality Subsystem of the Aerometric Information Retrieval System (AIRS). Information on AIRS can be obtained at: <http://www.epa.gov/ttn/airs/>. In addition, data from AIRS can be accessed via the Internet at: <http://www.epa.gov/air/data/index.html>.

**T3Q3** Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Ambient Monitoring Technology Information Center (AMTIC) contains information and files on ambient air quality monitoring programs, details on monitoring methods, relevant documents and articles, information on air quality trends and nonattainment areas, and federal regulations related to ambient air quality monitoring. This information can be found at <http://www.epa.gov/ttn/amtic/>

**T3Q4** To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The QA/QC of the national air monitoring program has several major components: the Data Quality Objective (DQO) process, reference and equivalent methods program, EPA's National Performance Audit Program (NPAP), system audits, and network reviews (Available on the Internet: [www.epa.gov/ttn/amtic/npaplist.html](http://www.epa.gov/ttn/amtic/npaplist.html)) To ensure quality data, the SLAMS are required to meet the following: 1) each site must meet network design and site criteria; 2) each site must provide adequate QA assessment, control, and corrective action functions according to minimum program requirements; 3) all sampling methods and equipment must meet EPA reference or equivalent requirements; 4) acceptable data validation and record keeping procedures must be followed; and 5) data from SLAMS must be summarized and reported annually to EPA. Finally, there are system audits that regularly review the overall air quality data collection activity for any needed changes or corrections. Further information available on the Internet: <http://www.epa.gov/cludygxb/programs/namslam.html> and through United States EPA's Quality Assurance Handbook (EPA-454/R-98-004 Section 15) There is a Quality Assurance Project Plan from each state or local agency operating a NAMS/SLAMS monitor meeting the AEPA Requirements for Quality Assurance Project Plans@, EPA QA/R-5. The quality assurance plans for specific sites are publicly available by request to the reporting agency or the corresponding EPA Regional Office. The plans are audited at least once every three years as required in 40 CFR 58, Appendix A, Section 2.5. In addition, the data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

**T4Q1** Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The air quality statistics presented relate to the pollutant specific NAAQS and comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators. A composite average of each trend statistic is used in the graphical presentations. All sites were weighted equally in calculating the composite average trend statistic. Missing annual summary statistics for the second through ninth years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates.

**T4Q2** Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. The data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

**T4Q3** Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No, We are not aware of any sources of error that may affect the findings developed from these data.

**T4Q4** Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The national air monitoring network for the six criteria air pollutants is extensive; however, there are far more monitors in urban areas than in rural areas. Monitoring in urban areas helps to characterize population exposures, because population tends to be concentrated in urban areas. More rural monitoring might help scientists assess transport and ecological effects, although EPA uses additional tools and techniques (e.g., models and spatial analyses) to augment limited monitoring in some areas and to better characterize pressures on ecological condition. EPA is currently conducting a national assessment of the existing ambient monitoring networks and is analyzing, among other issues, the need for and appropriateness of each of the nation's urban monitors. The monitoring is conducted mostly in urban areas, although the PM 2.5 data from the IMPROVE network support assessments of rural trends since the late 1980s. Trend data for PM10 are not available before 1988. Prior to 1988, total suspended particulate matter, which includes particles larger than PM10, was monitored to assess compliance with the NAAQS.